

# **THE INDUSTRIAL USE OF THE DATE PALM RESIDUES: AN ELOQUENT EXAMPLE OF SUSTAINABLE DEVELOPMENT**

**By**

**Hamed El-Mously**

Director of the Centre for Development of Small-Scale Industries  
Faculty of Engineering, Ain-Shams University

[cdsilt@idsc.gov.eg](mailto:cdsilt@idsc.gov.eg)

## **ABSTRACT**

The concept of sustainable development received great attention in the "Earth Summit" held in Rio de Janeiro in 1992 within the framework of the call of the Agenda 21 on all countries to promote sustainable consumption patterns. One of the most important responses to this call consists in the sustainable use of renewable material resources as a substitute for the non-renewable resources, such as fossil-based materials and metals.

The date palm is an essential element of the flora in the whole Arab World. In the past, date palm played a pivotal role in the economic, social, and cultural life in the Arab Region. Therefore, there is a need to rediscover, via research and development, the secondary products of the date palm such as palm midrib, leaflets, spadix, stem and coir, can be utilized and developed appropriately in industry. This research aims at finding some industrial use of date palm midrib. The date palm midrib was successfully used in Mashrabia handicrafts as a substitute for the imported beech wood. Another interesting application was the use of the midrib in the core layer of the blackboard as a substitute for the imported spruce wood without sacrifice of the utilization properties of the product. Three layer particleboard were successfully made of palm midrib as a substitute for casuarina wood. Besides, a lumber-like product has been successfully manufactured from the palm midrib enjoying physical and mechanical properties similar to those for imported wood. A super strong material approaching mild steel in strength has been successfully obtained from the date palm midrib. These findings illustrate that the industrial use of the secondary products of the date palm could be an eloquent example of leapfrogging, i.e. an example of sustainable development.

## INTRODUCTION

Perhaps mankind has never witnessed along its history such a moment of time like now when governments, as well as peoples all over the world are deeply concerned with the considerable mismatch between the prevailing path of development and the ecosystem. The previously admired patterns of production and consumption are now viewed as unsustainable and representing threats: not only to present but also to future generations. There is increasing recognition of the disconnect between the rising levels of production and most people's sense of individual and social well being [6]. The 19<sup>th</sup> and 20<sup>th</sup> centuries' almost "absolute": faith in science and technology as a panacea for all man's troubles has given way to increasing doubt in many of their achievements. There are increasing requirements to involve ethical considerations in scientific activity. Every now and then, hot debates rise between scientists belonging to the same field of scientific inquiry, but having different social or political stands, like those occurring between members of "unions of concerned scientists" and scientists, representing industrial firms, ironically called "concerns" scientists [21].

The appeal for cleaner production has given way to the appeal for ecoefficiency, i.e., ecodesign and dematerialization of production and further to sustainable production and consumption. At the present time, emphasis is being shifted to the consumption side, i.e. to the consumer himself. There is now a world-wide appeal for the empowerment of the consumer-and the whole civil society-to adhere to ethical consumption.

Most interesting in the international debate about sustainability is the general recognition that there are no single blueprints for making consumption and production sustainable in the North and in the South as well [15]. This provokes the feelings of collective responsibility of all in the North and the South. Over and above, some writings warn the South from emulating the Western pattern of development and stress the necessity of breaking with Western values [15]. Some others express their hope that the South may leapfrog the North using clean technologies which should not be necessarily modern [15]. For us, in the Arab region this situation is very stimulating. It challenges the forces of innovation. We are invited to proceed from our own cultural values and reorient our research and development activities to come to new ideas for the realization of sustainable development.

## **1. Sustainability: a view from the South**

Since the publication of the report of the World Commission on Environment and Development (WCSD) entitled *Our Common Future* in 1987, sustainable development has become a prime agenda in national and international scientific, politic and public fora. In the Earth Summit or the United Nations Conference on Environment and Development (UNCED) held in Rio De Janeiro, Brazil in June 1992, sustainable development was also the main theme. As defined by the WCED, sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [20].

This concept has two dimensions: a geographical/national-cultural dimension referred to in the previous definition by the words: “present generations”, and a temporal dimension, as referred to in the same definition by “future generations”. The first dimension, which we will call for simplicity the geographical, includes both the North and South. This dimension is usually not given due attention in literature and discussion on sustainable development (and sustainability in general) to the extent that it seems sometimes as if the industrialized countries are searching for the sustainability of their own standards of living. But if we take the geographical dimension into consideration, we will find that there are great differences in the contexts in the North and South. To start with, the issue of sustainability is not really a priority in many countries in the South, simply because the deterioration of the living conditions at present evokes the feelings of apathy to the future and to the future generations. Concepts like sustainable development or sustainability are far from being operationalized. They are mostly confined to come intellectual spheres and discussions in formal institutions and donor organizations active in these South countries. This doesn't mean that the issue of sustainability is irrelevant to these countries; it points to the fact that we need to develop different approaches or paths to sustainability in the North and South. Hereafter, two aspects of sustainability will be mentioned from a Southern perspective. The first, will be called technological sustainability, could be considered a point of weakness in most countries of the South. Conversely, the second aspect, the sustainable use of renewable material resources, could be a comparative advantage.

## **2. The date palm: a pivot of economic, social and cultural life in the Arab region.**

Perhaps no other tree has accompanied us along our history as the date palm. There is historical evidence about its existence in Egypt long before the dynasties and in Babilon and Sourth Iraq, 4000 BC. The date palm was one of the pivots of economic and, hence, social and cultural life in this region from ancient times. In ancient Egypt the heads of pillars in temples were made resembling the growing top of the date palm. The date palm appeared frequently on walls of temples in different contexts revealing its significance in life in Egypt. According to Nobian (South Egypt) traditions, when a child is born, they plant a date palm for him. When he has matured, the date palm will have grown to a number of palms, providing a basis for his future economic life. In Upper Egypt, each village has evolved beside its life-supporting palm plantations. The date palm is well adapted to our environment. It is grown well in the Nile Valley, where it gives gentle shade against the sun and protection from the wind to crops growing below it. It tolerates the harsh climate of the Sahara, making possible the life of Bedouins; it even tolerates high levels of salinity, growing along the seashore in Egypt. It needs much less water and service and is less subject to diseases and parasites than other trees.

Date, the primary product of the palm, is rich in protein, vitamins, and mineral salts. That is why it represents an essential element of diet for the cultivator himself and his animals (the low-grade date with kernel). All secondary products of the palm result from annual pruning (Fig. 1) and have essential uses for the cultivator. Thus, no waste results from the growing of palms. The date palm's midribs of grown palms after being woven in mat using coir ropes are used in roofing<sup>1</sup>. Crates for the transportation of vegetables and fruits are also made from the palm midrib, as well as furniture items, manual fans, doors of gardens and coops for chickens and rabbits. Midribs of young palms are used in fencing gardens. The midrib is used as floats for fishing nets or for fuel in rural ovens: the ashes being used afterwards in mortar. The leaflets are used after being

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<sup>1</sup> This was our first acquaintance with palm midribs. Roofs, made of midribs, lasting for centuries, were our first natural proof of their durability and good mechanical properties!

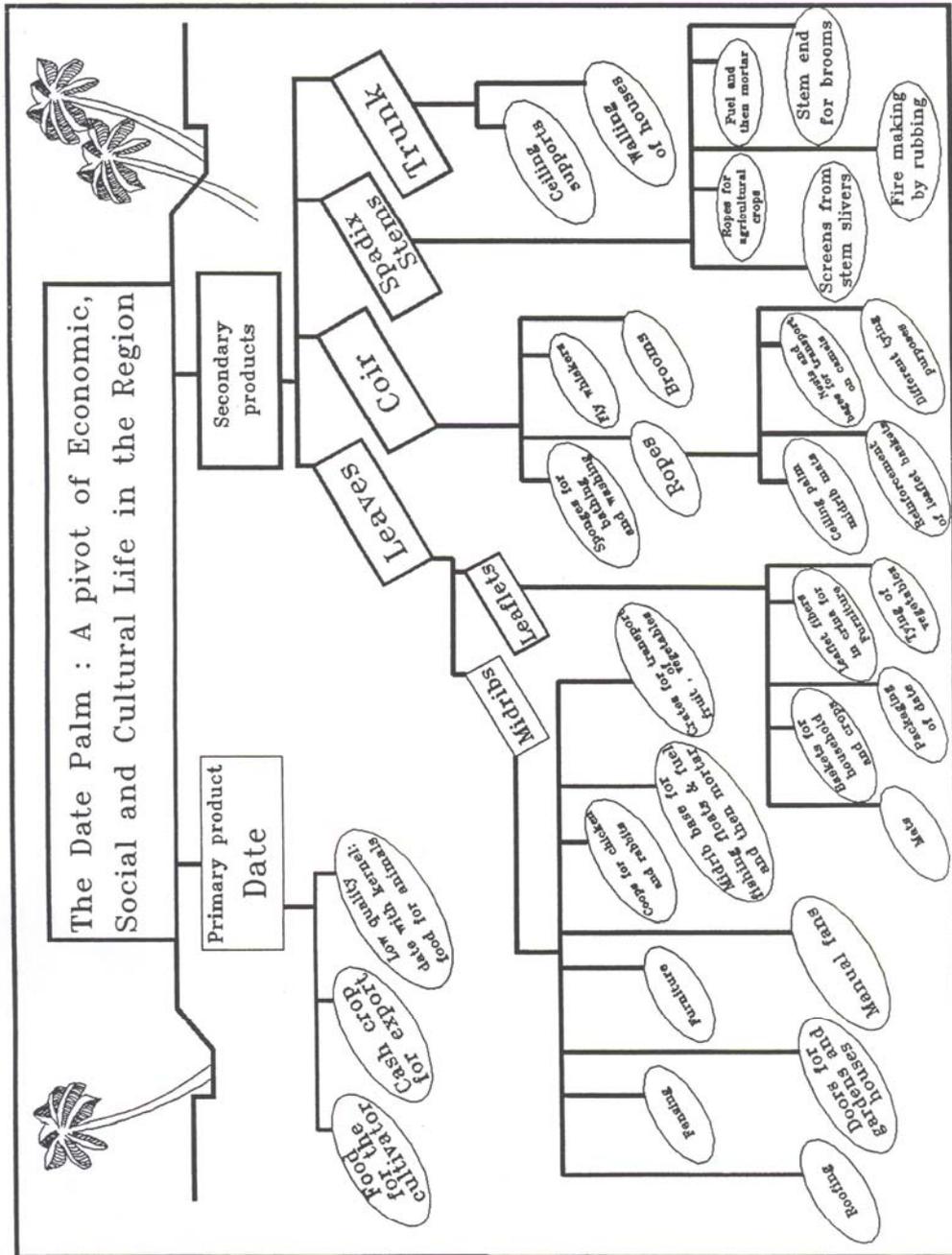


Fig. 1. A diagram showing the different forms of utilization of the date palm resources [9].

woven, in mat making, as well as in a very wide variety of baskets for use in the cultivator's household, as well as for transportation of various agricultural crops and packing of dates. They are also used for the manufacture of screens for households and as ropes for tying up vegetables. The leaflet fibers are used in the manufacture of crina used for stuffing of upholstered furniture. The coir is being used for making washing and bathing sponges, as well as for the manufacture of ropes for different uses. From coir, rope nets, and bags for the transportation of agricultural crops on camels are being made. Household brooms and fly whiskers are also made from coir. The spadix stem is crushed to obtain very strong fibers for tying up agricultural crops. The spadix stem ends with fruit stalks are used as brooms. Spadix stems of certain palm species were even used for fire making by rubbing. They were also used as coat hangers, and after being sliced into strips, were used for making screens for household use. The palm trunk is being used, after cutting it into halves or quarters as beams for ceilings or walling in rural and desert regions. **Thus, the date palm in our traditions represented an eloquent example of integrated sustainable use of renewable material resources.**

### **3. Rediscovery of the palm midrib: an example of the role of R & D**

It is clear from the aforementioned that the date palm found many genuine forms of utilization in our traditional way of life. We as researchers and intellectuals have to direct our forces of imagination and thinking to find new uses for these local resources within our own vision of sustainable development. This is what may be called the rediscovery of our natural resources.

As far as the palm midrib is concerned, it was found that this raw material is associated with the poor, whether producer (cultivators of palms, rural artisans manufacturing crates, etc.) or consumer (peasants in rural areas and Bedouins in oases). Thus the first step in our methodology consisted of the conduction of tests to determine the physical and mechanical properties of palm midribs and their comparison with the corresponding properties of wood. This is thought as a re-qualification or valorization for this raw material to open new avenues for its use within higher social strata in rural and urban areas. The research findings, Fig. (2), have shown that palm midribs enjoy physical and mechanical properties falling within values pertinent to known wood species as spruce and beech. **Hereafter are some examples of new avenues for use of the palm midrib.**

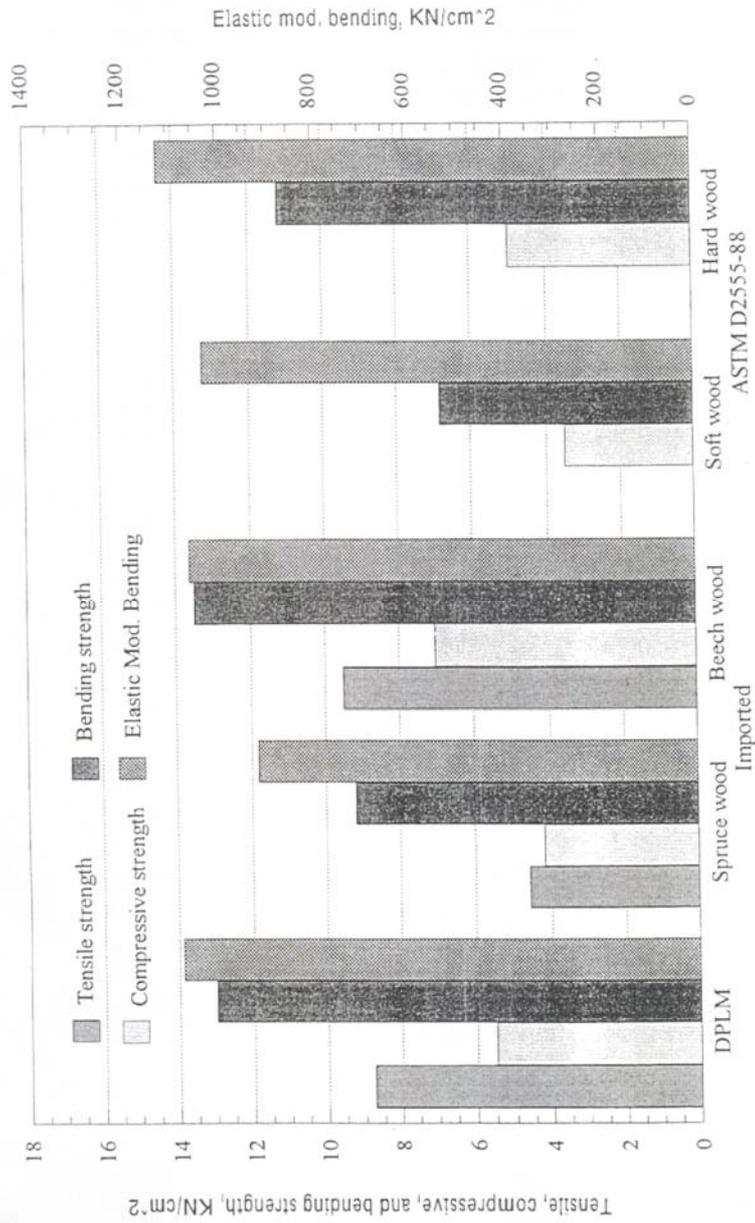


Fig. 2. Comparison between the mechanical properties of palm midrib and imported species of wood and their standard values in ASTM D2555-88 [11].

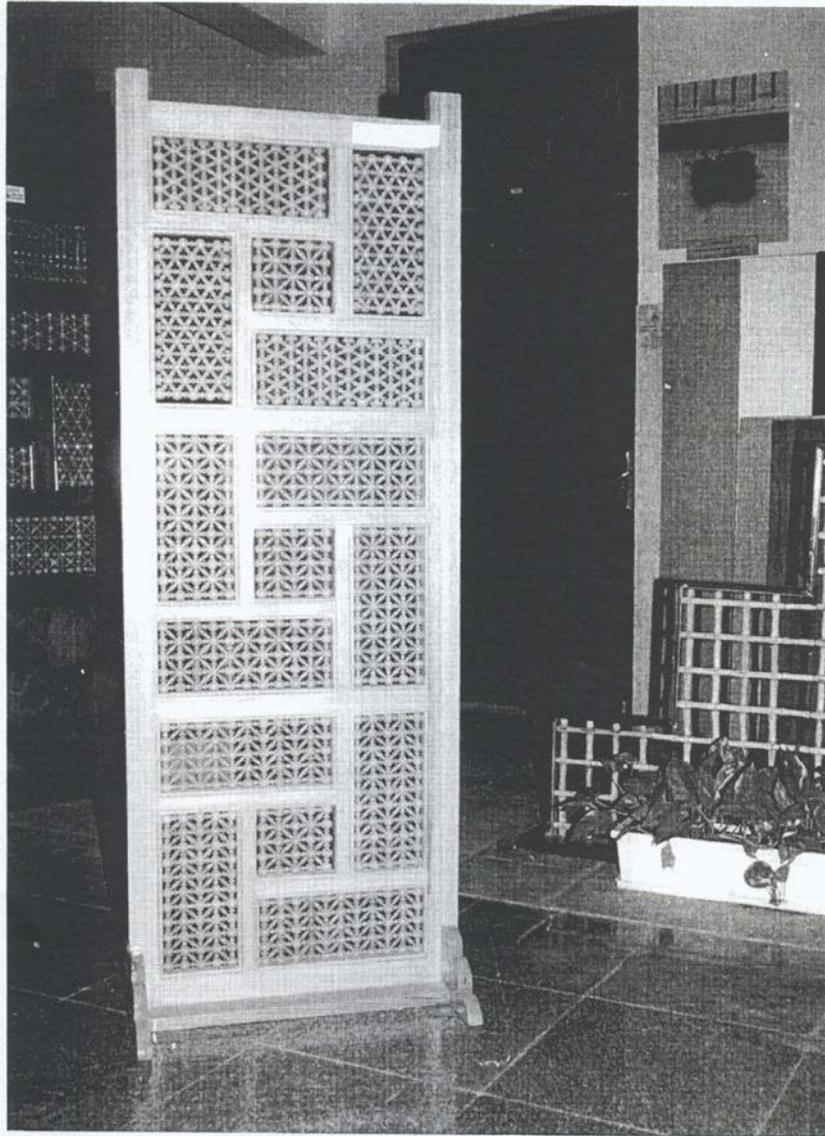
## 6.1 Arabesque from palm midribs

The Arabesque (Mashrabiah ) handicrafts are a part of our cultural heritage. The Arabesque items are being used in furniture, windows, and partitions (Fig. 3). The drastic increase in the price of imported beech wood, usually used for Arabesque, has led to the shrinkage of demand on Arabesque handicrafts. Therefore, it was thought that the replacement of beech wood by the cheap locally available palm midribs may open the way for the revival of Arabesque handicrafts, especially in rural areas. The Center for the Development of Small-Scale Industries launched on July, 1995 a project in the Dakhla oases in the New Valley Governorate to disseminate Arabesque handicrafts using palm midribs as a raw material. A training center was established to train the beneficiaries (Fig. 4), who obtain their lathes on a loan basis and produce at home. The project has shown great success turning the poor, especially women, to autonomous producers and entrepreneurs and transforming the idea of use of trees pruning products as a substitute for imported wood into reality.

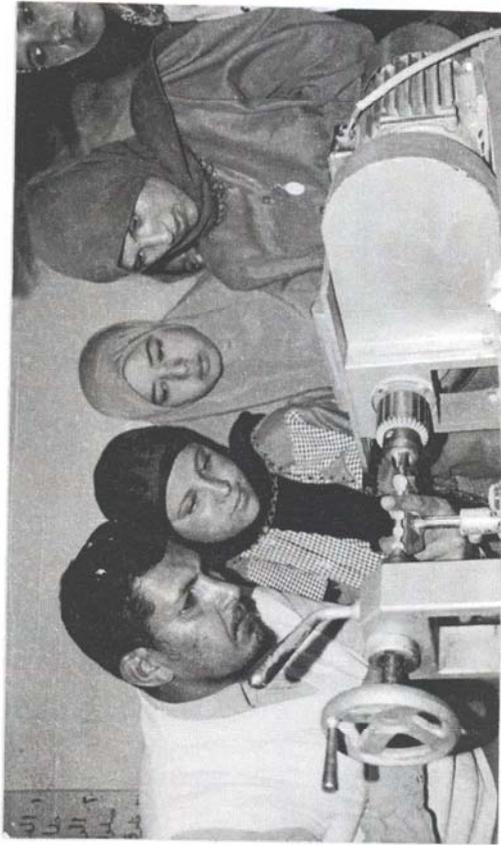
**The project opens a great potentiality of dissemination of a new culture of sustainable use of renewable material resources in rural and desert communities in the whole Arab region.**

## 6.2 Palm midribs in blockboard

Due to its full reliance on imported spruce wood, the blockboard industry in Egypt is in a critical situation. Therefore, it was decided to direct research to the use of palm midribs as a substitute for spruce in the core layer of the blockboard. The research results, Fig. (5), have proven that the palm midrib-core blockboard enjoys physical and mechanical properties comparable (and several of them superior to) those for spruce-core blockboard. Therefore, machines were designed and manufactured for the conversion of palm midribs into strips of uniform cross-section for the core layer. In a pilot experiment large batches of palm midrib core blockboards have been manufactured and samples sent for testing in München University Wood Research Institute. The results of tests, Appendix 1, have proven the high quality of these blockboards as compared with those manufactured from wood. Within this pilot experiment the school furniture for 100 community schools in villages in Upper Egypt was successfully manufactured from palm midrib core blockboards, which was highly praised by the UNICEF, appendix 2.

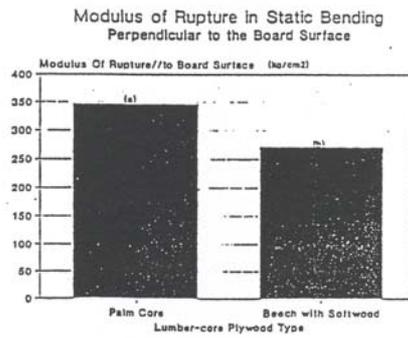
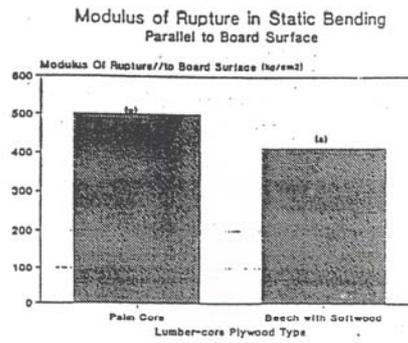


**Fig. 3.** A partition from palm midribs.  
(Source: El-Mously, H.I., Centre for  
Development of Small-Scale Industries).



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**Fig. 4.** Training of beneficiaries on Arabesque handicrafts from palm midrib.  
(Source: El-Mously, H.I. Centre for Development of Small-Scale Industries).



**Fig. 5.** Results of tests of comparison between the modulus of rupture (MOR) for specimens of date palm core blockboard and commercial spruce-core blockboard [11].

### **6.3 Particleboards from palm midribs**

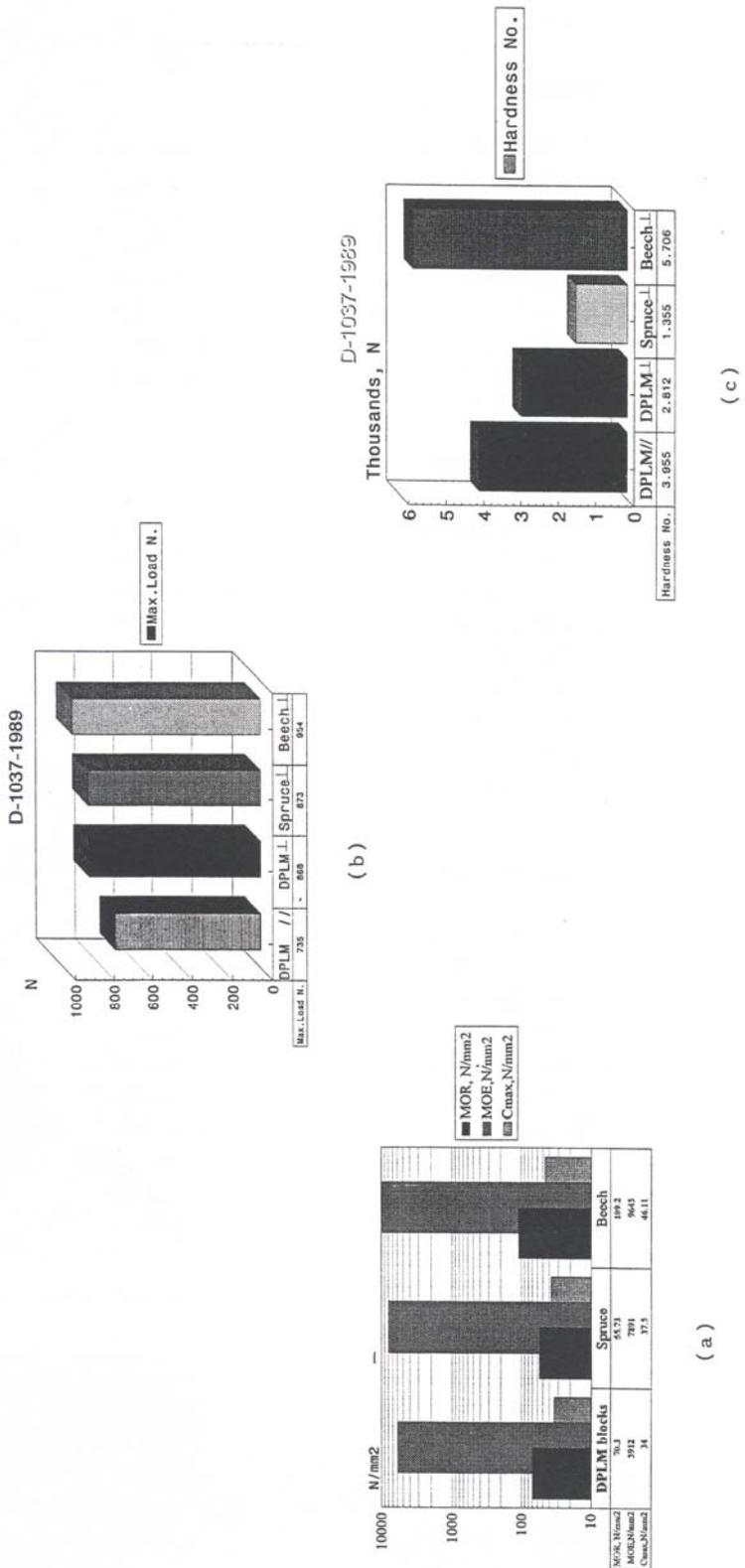
It has been proven that the ratio of utilization of palm midribs in Arabesque and blockboard does not exceed 40%. Therefore, research was conducted to use these midrib residues in particleboard manufacture. The results have proven that particleboards manufactured from palm midribs enjoy physical and mechanical properties satisfying the Egyptian particleboard standard 906/199 [10]. This opens the way for the development of a particleboard industry, and MDF as well, complementary to Arabesque or blockboard industries, to satisfy the objective of integrated use of the palm midrib.

### **6.4 A lumber-like product from palm midrib**

As a response to the acute shortage and high prices of wood in Egypt, a research has been conducted to investigate the possibility of manufacture of a local substitute of solid wood, made from palm midribs. The research results, Fig. (6), indicate that palm midrib blocks enjoy values of modulus of rupture (MOR) and other mechanical properties similar to those for red pine and spruce. This opens a great potentiality for use of palm midribs to manufacture products that could substitute imported solid wood in Egypt and the whole Arab region. This research has been awarded the Euromat-97 conference prize for the best poster, 21-23 April 1997, Maastricht (Appendix 3).

### **6.5 A super strong material from the palm midrib**

The anatomical structure of the palm midrib has shown that the outer layer differs from the inner part of the midrib by a higher density and smaller diameter of the fibro-vascular bundles. This suggests that this outer layer may have better mechanical properties, as compared with the average properties of the midrib. Besides, this layer constitutes an unused residue of the palm midrib-blockboard industry. Thus, research was conducted to determine the tensile strength of the outer 1.25-mm layer of the midrib. The research results (See Table 1) clearly indicate that the outer layer of the midrib enjoys a tensile strength ( $\sim 25 \text{ kg/mm}^2$ ) comparable with that of commercial steel. As far as the specific strength is concerned, i.e. tensile strength per unit weight, the outer layer is 4 times higher than steel. This indicates that the palm midrib outer layer is a super strong material that could find wide applications in industrial composites.



**Fig. 6.** Results of comparison between several mechanical properties of palm midrib blocks with several wood species:  
**a.** MOE, MOE and  $C_{max}$ ;  
**b.** Nail with drawal test;  
**c.** Hardness test [19].

**Table 1 – The values of tensile strength and specific tensile strength for palm midrib outer layer, compared with several wood species and steel [12].**

| Material           | Tensile strength (N/mm <sup>2</sup> ) | Specific tensile strength (N/mm <sup>2</sup> )/(g/cm <sup>3</sup> ) |
|--------------------|---------------------------------------|---------------------------------------------------------------------|
| Outer layer        | 248                                   | 196                                                                 |
| Inner layer        | 70                                    | 86                                                                  |
| European read pine | 78                                    | 142                                                                 |
| Beech              | 97                                    | 140                                                                 |
| Steel 37           | 367                                   | 46                                                                  |

## **6.6 Use of palm midribs in space trusses**

In one of the ongoing research activities<sup>(1)</sup> palm midribs are being used as members in space trusses. The research results are encouraging in terms of the load carrying capacity, elastic deformations, as well as cost. The success of the use of palm midribs in space trusses opens a new field for the use of palm midribs in low-cost roofing, as well as in ecofriendly tourist establishments.

## **7. The date palm residues: future prospects.**

### **7.1 New opportunities for palm residues**

The growing environmental consciousness, especially after the Earth Summit in 1992 in Rio De Janeiro has created a new situation, in which not only the non-governmental associations, such as the consumer associations and environment-action groups like Green peace, Milieudefensie, etc. are environment-active, but also the governments! The government's legislation, especially in Europe, gives considerable care to environmental issues. There is now legislation putting great pressure on dumping or incineration of waste and defining what is called: "producer responsibility for recycling of products after use." Among the legislations are the EC-Guidelines "Packaging and waste of packaging," which will be valid for all packaging that will be brought to the European market [8]. As stated

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<sup>(1)</sup> A Ph.D., Instit. of Env. Studies and Res. Ain Shams U. Cairo.

before, a general preferential system was worked out stating that preference could be given to products from developing countries, which are produced in a more environmentally friendly way. Within this context, the renewable material resources, such as palm residues may have quite challenging new opportunities in new avenues of utilization. **Here are several examples:**

- Improvement of some traditional uses of palm residues through new treatment and new designs of products:
  - ◀ Manufacture of baskets from palm leaflets.
  - ◀ Manufacture of crates from palm midribs.
- New avenues of utilization as a substitute for other materials:
  - ◀ Use of coir and leaflets as a packaging material, upholstery, mattresses, floor covering, etc.
  - ◀ Use of coir and leaflets as an isolation material.
  - ◀ Manufacture of biocomposites using palm midrib and spadix stem fibers as a substitute for fiberglass in composites and replacing plastics by natural glues.
  - ◀ Use of palm midrib, spadix stem and leaflets in gypsum-fiber and cement-fiber boards. Thus, the palm residues may replace wood fibers in many uses.

## **7.2 Palm residues as a substitute for wood in the Near East**

The increase in the environmental concern during the last decades has led to an acute shortage in the available wood in the international market. As an example, in the USA the rate of cutting wood in the federal forests has been decreased to  $\frac{1}{4}$  its value in 1980 [18]. Subsequently, this has led to the soaring of wood prices. The main response to the shortage of wood in Western countries is found in the tendency to improve the efficiency of utilization of natural timber (e.g. the use of particleboards, oriented strand boards and medium density fiberboards (MDF) instead of natural wood, guaranteeing a higher rate of utilization) and/or the use of lower grade wood species in composition panels. The response in Southeast Asian countries was basically to use bamboo and rattan and the agricultural residues of annual crops as a substitute for wood in panels. The range of products range from: blockboards, particleboards, MDF and furniture. The

annual size of sales of bamboo and rattan products could be estimated by 4.5 and 7 billion US \$ respectively [5].

As far as wood resources are concerned most of the Arab countries are located in an arid zone. This makes them very poor in forest coverage. Therefore, most of the Arab countries rely basically on importation for the satisfaction of their needs in wood and wood products. The average annual cost of wood imports in Egypt during the period 1996-2000 is about 2 billion L.E. [13]. This value is expected to increase in future with the increase of population and the expected soaring of prices of wood in the global market. The same holds for most of the Arab countries.

Fig. 7 illustrates the distribution of palms in millions in the Near East. It is obvious that the leading countries in palm plantations are Iran, Iraq, UAE, Saudi Arabia and Egypt. The total annual amounts of palm residues resulting from pruning of palms could be estimated, (Fig. 8), by: 1.3 million tons of palm midribs, 1 million ton spadix stems, 1.3 million tons leaflets and 0.2 million tons coir (dry weight). Therefore, we should raise the motto: substitute palm residues for wood in the Near East.

Let us compare the date palm with the spruce tree. Assuming an average maturation period for a spruce tree of ~ 90 years, a stem diameter of 35 cm, merchantable length of 15 meters, a tapering reduction ratio of 0.60 and a density of 0.38 g/cm<sup>2</sup>, thus the useful dry wood crop will be equal to 0.33 ton. Assuming an average lifetime for a palm of 100 years, the total amount of dry residues will be equal to 3.53 tons. This means that during its life, a date palm renders a crop of lignocelluloses material more than ten times that of the spruce, in addition to the date, of course. This opens the way to a new concept of afforestation more appropriate to our region: afforestation to obtain food and lignocelluloses materials that may serve as wood substitutes and other industrial uses. Besides, and perhaps more important, the date palm points to a new ethos from the sustainability perspective: you can obtain your “wood” not by cutting or killing trees, put by serving (pruning) palms.

### **7.3 Organizational measures to support the date palms**

It is clear from the foregoing that the destiny of millions of citizens in the Arab countries is associated-at present and in future-with the date palms. Hereafter are suggested organizational measures to support the date palms in the region within the framework of sustainable development.

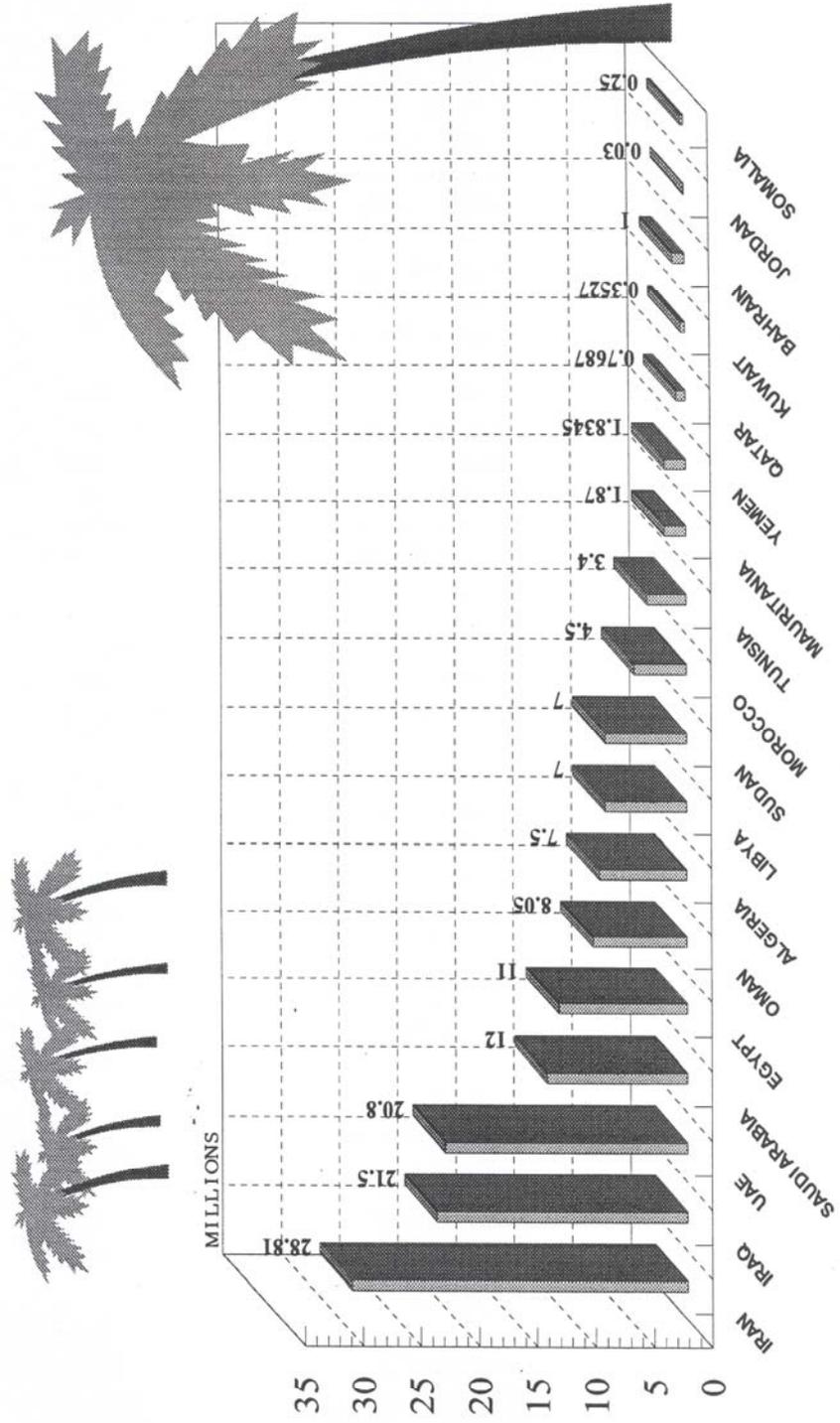


Fig. 7. Distribution of date palms in the Near East region [1] and [3].

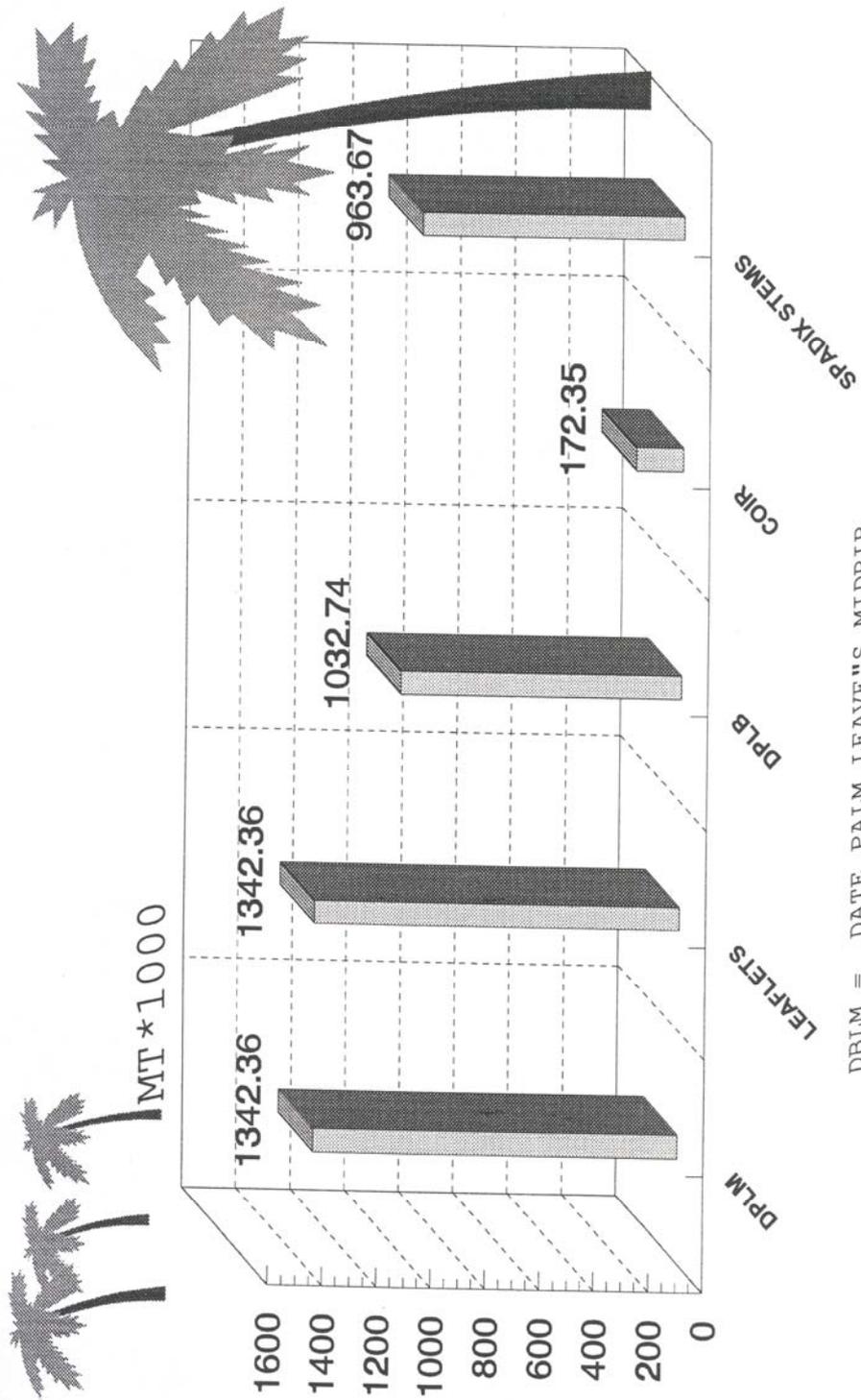


Fig. 8. Estimation of the annually available palm residues (in 1000 metric tons dry weight) in the Near East region [1]. Estimates of palm residues have been made according to [2].

### **7.3.1 Afforestation by palms and not by wood trees**

Governments should set plans for greening of streets, public areas and gardens by date palms instead of other ornamental trees. Beside the supply of date, palm residues could serve as a base material for a wide spectrum of micro-, small-and medium-scale industries that could be a very efficient vehicle for the endogenous development of local communities in the region.

### **7.3.2 Organization of local, national and regional networks.**

Nongovernmental organization should be organized, whose objectives may range from the support of cultivators of date palms, producers of handicraft products from palm residues, researchers, marketing etc. One of the most encouraging steps in this concern is the establishment of the Regional Network for Date-Palm in the Near East and North Africa in March 2000. It is suggested that the scope of work of this network should be extended to include non-food uses of the date palm residues, some of which have been presented in this paper.

### **7.3.3 Entrepreneurs and investors**

It is suggested to establish small-and medium-scale enterprises for pruning of palms. The domain of operation of such enterprises should be defined on a regional basis (i.e., by defining the appropriate territory of each company's region). The scope of activities of such enterprises includes: pruning of palms, handling and processing of palm residues up to the manufacture of finished products from these residues. The governments could establish their own "preferential systems" to encourage the industrial utilization of palms residues giving preference for products, manufactured from palm residues as renewable environment-friendly material resources. Therefore, the governments could use their demand on wood, or wood-like, products as a mean for encouraging the industrial use of palm residues within the framework of sustainable development.

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